

THE U.S. NAVY ADS2000

Beginning a New Era in Submarine Rescue

Jim Gibson
Jim English

OceanWorks International Corporation
#3 - 1225 East Keith Road
North Vancouver, BC
Canada V7J 1J3

ABSTRACT

The ADS2000 is first component of the manned rapid Assessment Underwater Work System (AUWS) segment of the U.S. Navy's future Submarine Rescue Diving and Recompression System (SRDRS). The ADS2000 provides a rapid response capability for DISSUB localization and assessment, hatch clearance, and emergency life support stores (ELSS) replenishment. The dually redundant ADS 2000 system consists of:

- Two ADS2000 atmospheric diving suits – depth rated to 610 m, with all life support, thrusters, communications, navigation and emergency accessories.
- Two Launch & Recovery main skid assemblies complete with self-erecting A-frames, main and secondary winches, head frames and Tether Management Systems.
- One control van, spares van, and miscellaneous mission support equipment and spare parts.

The ADS2000 interior remains at one atmosphere, allowing the pilot to operate at depths to 2000fsw for extended periods and return directly to the surface, without the attendant costs and risks associated with decompression. The ADS2000 limbs achieve diver like dexterity through the use of low friction rotary joints and manipulators that maintain flexibility and full range of motion at all depths. The ADS2000 represents the future direction of diving and submarine rescue systems.

INTRODUCTION

OceanWorks International's subsidiary, OceanWorks International Corporation (OWC) of North Vancouver Canada was selected by the U.S. Navy to design, and fabricate the "ADS2000" and fly-away launch and recovery system (LARS). The ADS2000 program is the first component of the manned, Rapid Assessment



ADS2000
Atmospheric Diving System (ADS)

Underwater Work System (AUWS) segment of the U.S. Navy's future Submarine Rescue Diving and Recompression System (SRDRS). The ADS2000 represents a significant step forward in submarine rescue and subsea intervention technology.

The ADS2000 program has been a team effort between OceanWorks International Corporation and the United States Navy. It demonstrates OWC's ability to develop, integrate and operate systems to meet the stringent certification requirements of military customers, and represents the future direction of diving and submarine rescue systems.

OceanWorks International completed an at-sea demonstration of the ADS2000 system and the LARS Tether Management System (TMS) during builder's trials conducted at Fox Island, Washington in January 1998. Full-suit strain gauge testing to 3000 feet of seawater (FSW) was conducted at the Naval Surface Warfare Center (NSWC) Carderock Division, Bethesda, MD in June-July 1998.

OceanWorks International completed a manned 2000ft dive and performed functional demonstrations of the suit at the Navy Experimental Diving Unit (NEDU) Panama City FL, Ocean Simulation Facility (OSF) complex in September 1998. OWC delivered the first ADS2000 to the U.S. Navy in September 1998. OWC has since completed the manufacture of three (3) additional suits and (at the time of this paper) is awaiting Factory Acceptance Testing (FAT), and final system certification.

US NAVY SUBMARINE RESCUE DIVING AND RECOMPRESSION SYSTEM (SRDRS) OVERVIEW

The U.S. Navy Submarine Rescue Diving and Recompression System (SRDRS) is a fully integrated submarine rescue system to provide a rapid response submarine rescue system using 21st century technology. The SRDRS is composed of three distinct systems. (See Figure)

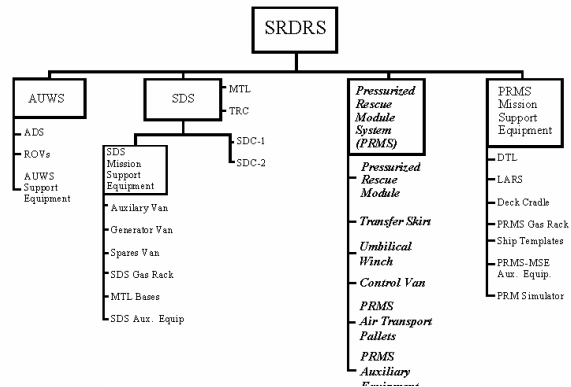
The first system is the Assessment/Underwater Work System (AUWS). It consists of Atmospheric Diving Suits (ADS), Remotely Operated Vehicles (ROVs), and associated AUWS Support Equipment that will be used with both the ADS and ROV. AUWS is the first SRDRS system mobilized in response to a SUBMISS/SUBSUNK event. It will provide capability for disabled submarine (DISSUB) localization, rapid assessment of the DISSUB conditions, hatch clearance, and Emergency Life Support Stores (ELSS) Pod replenishment.

The second system is the Submarine Decompression System (SDS). The SDS is composed of two large Submarine Decompression Chambers (SDCs) and associated SDS Mission Support Equipment (SDS-MSE). The SDS provides controlled decompression of DISSUB rescues or escapees.

The third system is the Pressurized Rescue Module System (PRMS). The Pressurized Rescue Module (PRM), is a tethered, manned Remotely Operated Rescue Vehicle (RORV) that is used to shuttle personnel in groups from a disabled submarine (DISSUB) to the surface. The Pressurized Rescue Module System (PRMS) also includes PRMS Mission Support Equipment (PRMS-MSE).

The PRMS is capable of being launched and recovered from a range of different vessels of opportunity (VOO). The PRM is commanded and controlled remotely from the surface in order to navigate, descend, maneuver to, and mate underwater with a bottomed, internally pressurized DISSUB. It has two (2) attendants onboard to assist with the transfer of sixteen (16) rescuees and to control and monitor life support functions. It is capable of ascending to a submerged Cursor Frame suspended from the Launch and Recovery System (LARS) where it docks and is recovered onto the deck of the support VOO. It has a dedicated Horizontal Manway capable of mating with the Deck Transfer Lock (DTL) to permit the direct Transfer Under Pressure (TUP) of rescuees and attendants into the SDS decompression chambers on deck.

Both the PRMS and SDS are designed for rapid deployment via air and ground transport and for mobilization aboard military or commercial VOOs. This configuration eliminates current rescue system's dependence on specially configured mother submarines (MOSUBs) or dedicated surface support ships. Both the SDS and PRMS operate from a set of integrated Ship Interface Templates attached to the deck of a VOO. Both systems also share certain sub-system functions and resources.



ADS2000 SYSTEM DESCRIPTION

The ADS2000 (or HARDSUIT™ 2000) system is designed to provide rapid mobilization for any operational subsea tasking to include disabled submarine (DISSUB) response, and salvage operations. The small “footprint” of this system allows it to be easily airlifted to any location and installed on a vessel of opportunity. The HARDSUIT™ is easily deployed to survey and establish contact with the DISSUB, and commence stabilization of the DISSUB condition through use of the Emergency Life Support Stores (ELSS) Pod system and/or the Decompression – Ventilation System.

The HARDSUIT™ interior remains at one atmosphere, allowing the pilot to operate at depths to 2000fsw for extended periods and return directly to the surface, without the costly and risky decompression which often plague conventional divers.

The HARDSUIT™ limbs achieve diver like dexterity through the use of patented rotary joints that maintain flexibility and full range of motion at all depths. The high performance thruster pack allows the pilot to fly

and work in mid water. The pilot can work anywhere from upright to fully prone (front or back). The ability to use the legs for fine positioning on bottom or to reduce overall height is a significant advantage when working in and around subsea equipment.

The HARDSUIT™ has ROV like range and manoeuvrability, with the advantage of being small enough to gain access to restricted spaces and perform intricate useful work, previously the exclusive domain of divers.

The ADS2000 system consists of:

- Two ADS2000 atmospheric diving systems – depth rated to 610 m, with all life support, thrusters, communications, navigation and emergency accessories.

- Two Launch & Recovery main skid assemblies complete with self-erecting A-frames, main and secondary winches, head frames and Tether Management Systems.
- One dual pump/motor hydraulic power unit. One main power distribution unit.
- One control van with all topside controls and systems for simultaneous operation of two HARDSUIT™ systems. Van includes a work shop and spares storage area and tools.
- One comprehensive spare parts package, system manuals and documentation.

ADS2000 SYSTEM DESCRIPTION SUMMARY

| | |
|-------------------------------|---|
| <i>Depth Capability:</i> | - ADS2000 Series 2000 Fsw (610 m) depth capability |
| <i>Height:</i> | - 82 in (208 cm) - adjustable to fit an operator from 5' – 8" (142cm) to 6' – 5" tall (165cm) |
| <i>Width:</i> | - 48 in (122 cm) |
| <i>Weight (topside):</i> | - 960 lbs (436 KGs) <i>Weight:</i> (in water) - 4-8 lbs. (2-4 KGs) flying mode |
| <i>Hull Material:</i> | - 6061 T651 Forged Aluminum |
| <i>Propulsion System:</i> | - Constant speed, Variable Pitch. |
| <i>Power:</i> | - 2 x 2.25 HP - 400 Hz |
| <i>Control:</i> | - Left Foot - Vertical control, Right Foot - Lateral control |
| <i>Life Support:</i> | - Oxygen re-circulation with fan powered CO ₂ scrubbing capability. - Back-up oral/nasal lung powered emergency CO ₂ scrubber - Dual independent Oxygen system - Port & Starboard |
| <i>Life Support Duration:</i> | - 6-8 hour normal dive time with 48 hours emergency life support |
| <i>Safety / Emergency:</i> | - Ballast Jettison capability - Thruster (Propulsor) Jettison capability- Tether Cut / Jettison capability - Radio frequency Beacon / Xenon strobe - Emergency 37.5 kHz Pinger |
| <i>Equipment:</i> | - Dual on-Suit Video Camera capability - On-Suit Color Imaging Sonar - AMS (Atmospheric Monitoring System) - Surface monitoring ability for: HPO ₂ , CO ₂ %, Cabin Press, O ₂ %, Depth, Temp. - Hardwire Digital communications - Acoustic underwater telephone |

DESIGN EVOLUTION OF THE “ADS2000”

OceanWorks International Corporation undertook the design and production of the ADS2000 as a deepwater evolution of its commercial HARDSUIT™ Atmospheric Diving System (ADS).

The U.S. Navy originally acquired a commercial version of the HARDSUIT™ under the Foreign Comparative Test (FCT) program in 1994. The HARDSUIT was evaluated in a series of tests conducted by the Naval NUWC Coastal Systems Station (CSS) in Panama City, Florida. These tests resulted in the conclusion that ADS technology of the commercial HARDSUIT™ design offered the best solution to Navy's future submarine rescue requirements. The challenge would be to configure design to meet U.S. Navy certification requirements. At the same time the U.S. Navy decided to upgrade the depth rating to 2000fsw to meet SRDRS operational objectives.

In June of 1996 OceanWorks International was awarded a contract to design and build the "ADS2000" as a commercial product with the added specification that it meet the certification requirements of U.S. Navy's Deep Submergence Certification standard, NAVSEA SS800-AG-MAN-010/P-9290.

Meeting the P- 9290 requirements resulted in a significant shift in the pressure hull fabrication methods used for suit fabrication. The HARDSUIT™ 1000fsw and 1200fsw systems use cast aluminum pressure hull components. This allows for cost-effective production of the complex curved shapes necessary to achieve a compact size and close ergonomic fit. The P-9290 rules imposed criteria that demanded the pressure hull components be fabricated from forged aluminum material. This resulted in the need for all complex shapes to be CNC machined to extremely tight tolerances. P-9290 also imposed significant requirements for linear and non-linear finite element analysis, systems functional analysis, and Quality Assurance testing and documentation.

A more detailed summary of the ADS2000 system is found in the following section.

ADS2000 PRODUCT SPECIFICATION

Depth Capability

- HS2000 MkI 2000 fsw (610 m)
- Maximum allowable working pressure (external) - 890 psig
- Maximum allowable working pressure (internal) - 15 psig

- Proof test pressure 1.5 x operating depth - 1340 psig
- Internal Volume 6.68 cu ft.
- Suit operating temperature 28°F – 75°F (submerged) *governed by Vision Dome*

Hull Material

- Hand forged aluminum 6061 T6/T651/T652 and T654 temper
- Minimum strength in all directions 38 ksi
- Pressure boundary forgings manufactured in accordance with ASTM B247 (*with modification*)
- Hull quality conforms to ASTM test requirements:
 - ASTM B247, B209 and B211
 - ASTM B557
 - ASTM E9
- Hull and all critical implodable volume components comply with requirements of SS800-AG-MAN-010/P-9290 Rev A (*dated November 3rd 1998*)

Vision Dome

- Reynolds Polymer Technology R-Cast® acrylic window fabricated to PVHO-1-1997
- Maximum Allowable Working Pressure Rating 890 psig
- Outside Diameter 15.475”
- Average thickness 1.3”
- Included Angle (Angle of View) 105°
- Maximum Operating Temperature 75°F
- Minimum Operating Temperature 28°F

Fixed Buoyancy

- Floatec Syntactic Foam Type Floatec 1000 - 3000fsw rated (*32 +/- 1 lb per cubic feet density*)
- Three Modules:
 - Upper Torso
 - Lower Torso Forward
 - Lower Torso Aft

N.B. *Lower Torso floatation modules are coated with urethane elastomer for abrasion protection*

Damage/Abrasion/Protective Coatings

- Pressure hull/boundary components - clear hard anodized inside and outside
- Limb and Waist Extensions - Anodized royal blue
- *Anodizing meets the requirements of MIL-STD 8625/F*

Life Support

- Suit ambient air re-circulation with fan powered CO₂ scrubbing capability. System features a back-up oral/nasal lung powered emergency CO₂

scrubbing capability. (Dual independent oxygen systems port and starboard)

- Oxygen System
- HPO₂ maximum allowable working pressure 2216 psig
- Reduced O₂ operating pressure range 80-120 psig

All piping hydrostatic tested to meet the requirements of SS800-AG-MAN-010/P-9290 Rev A (*dated November 3rd 1998*) which complies with all applicable ASTM and ASME codes and MIL-STD 1330. All piping brazed in accordance with ASME Section IX

CO₂ Scrubber

- Capacity 8.84 kg of soda lime 4-8 mesh (19.5 lbs)
- Effective operating time - Normal 6-8 hours
Emergency 48 hours
- Back-up scrubber fan battery life - 4 hours

Propulsion System

- Constant speed, Variable pitch - Power 2 x 2.25 hp – 440 VAC 400 Hz
- Control is by means of Pilot Foot Controls
Left Foot – vertical control
Right Foot – lateral control

System Power

- Surface Module Power - 1000VA uninterruptable power supply 50/60 Hz 110/220 VAC
- Propulsor Power – 440 - 50/60 Hz – 3 phase
- Suit Power - 110/220 VAC - 50/60 Hz - Single Phase
- Line Insulation Monitor - Monitors ungrounded power supplies (suit and propulsor power). Response time 20ms at 30mA leakage.

Communications

- Hard wire Digital Communications - Seaphone Model 3700
- Thru water Communications - Orcatron Subphone Diver Station
- Underwater Telephone Transducer - Orcatron 27 KHz Model No. EE2014

Safety / Emergency Equipment

- VHF radio direction finder beacon with pressure switch - Novatech RF 700A1
- Xenon strobe light with pressure switch - Novatech ST-700A
- Ballast Jettison capability
- Thruster (propulsor) Jettison capability
- Tether Cut / Jettison Capability
- Emergency pinger mode on UWT - 37.5 kHz

Navigation and Vision Systems

- Imagenex colour scanning sonar - Model No. 881-000-103
- Kongsberg PTF colour video camera with integral pan and tilt - Model No. OE 1386
- External Lights (2) Deep Sea Power and Light Mini Sealight
- Analog compass

Atmospheric Monitoring System

- Computer Based System with user-defined alarms and topside monitoring capability for HPO₂ pressure, CO₂%, Cabin Pressure, O₂%, Depth and Temperature.

Manufacturer: OceanWorks International Corporation

#3 - 1225 East Keith Road
North Vancouver, BC
Canada V7J 1J3
Tel: 604-986-5600
Fax: 604-986-7125

Corporate: OceanWorks International Inc.
1646 West Sam Houston Parkway
Houston, Texas 77043
Tel: 713-933-8000
Fax: 713-933-8006

THE FUTURE

Interest in atmospheric diving technology has increased three-fold since the tragic loss of the submarine Kursk.

The operational, safety and lifetime support cost advantages of the ADS200 place it in the lead role to meet future manned diving and submarine rescue systems requirements. Once certified, it is planned that the system will be operated and maintained as a Government-Owned-Contractor Operated (GOCO) system based at Navy's Deep Submergence Unit (DSU) in San Diego, CA ready to respond to any emergent operational tasking.

In November 2001 the design effort of the OWC - US Navy Team were acknowledged when Popular Science awarded the ADS2000 the "Grand Award" for best new invention of 2001, and Time Magazine recognized the suit as one of the "best new (Technology) inventions" of the year.